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Roberta E. Lutz, Contract Administrator
Department of the Navy
Office of Naval Research
University of California, Berkeley Office
Richmond Field Station
Richmond, CA 94804-0001

Dear Ms. Lutz:

This is our final report for Grant USN00014-90J-1866. The covered reporting period is 1 May 90 through 31 Oct. 91.

The goal of our study was to examine peripheral adaptation, and especially any effects it might have on tuning properties. One component of the study depended on custom-made equipment-- for automated determination of single-unit tuning curves. Unfortunately, in spite of being ordered at the beginning of the grant period, this equipment did not arrive until the later part of the 6-month no-cost extension period. This component of the project has not even been started yet. We intend to complete it, however, and to credit the grant for the equipment necessary to do so.

In spite of this problem, we had a full 1.5 years worth of completed projects that addressed the issues of the proposal. These have resulted in three published articles, and two manuscripts in press in HEARING RESEARCH. Additionally, we are still analyzing data that we expect to lead to two more papers. We have acknowledged this grant in the five articles and manuscripts, and will do so as well in the manuscripts in preparation.

Our work consisted of single-unit studies of the amphibian papilla of the bullfrog and single-unit and CAP studies of the cochlear nerve of the gerbil. We have divided these into five categories: (1) REVCOR studies of the dynamics of tuning-property changes during adaptation. (2) Cycle-histogram studies of the dynamics of ac gain changes during adaptation. (3) Demonstration of one-tone suppression, which seems to be akin to adaptation. (4) Studies of the possible adaptation of peripheral auditory units to the sounds of the animal's own heart. (5) Enhancement of CAP amplitude as a possible example of release from adaptation.

(1) REVCOR studies (data being analyzed). Using high-resolution (1024-bin) REVCOR, we studied the linear tuning properties of bullfrog amphibian-papillar units and gerbil cochlear units as functions of time after stepwise changes in the amplitude of noise stimuli. As was previously reported by Carney & Yin for cat cochlea and by Moller for rat cochlea, the impulse

responses of cochlear filters in the gerbil and bullfrog are shortened conspicuously when the level of the REVCOR noise stimulus is increased. The concomitant broadening of tuning is clearly present, but not as conspicuous as the shortening of the impulse response. Using multiple repetitions of identical 20-dB steps in noise amplitude and carrying out REVCOR analysis over fixed time intervals before and after the step (e.g., the 10 ms just after the step), we looked for evidence of gradual change in the shape of the impulse response following the step (i.e., we hoped to follow the dynamics of change and thus learn more about the possible underlying mechanisms). We found that, in response to a step increase of noise level, the shape changes of the impulse response consistently are completed in times that are short compared to the duration of the impulse response itself. This is true in frog and gerbil. Thus the dynamics of those changes are unobservable with REVCOR methods. So far, in response to step decreases in noise level, we have found subtle evidence (in both frog and gerbil) that the shape-changes may take longer and may be observable. Unfortunately, adaptation reduces the number of spikes available for REVCOR analysis in the first few tens of milliseconds after the step-- making the observations difficult. We are continuing to analyze the data and will obtain more if need be.

(2) Cycle-histogram study (data being analyzed). In this study we combined a tone generated digitally with noise generated by analog means. By means of digital control, the amplitude of the noise was stepped repeatedly between two or more levels. The steps occurred at a fixed phase of the tone sinusoid. We thus were able to carry out cycle-histogram analysis to determine whether gradual changes in ac (linear) gain occurred following a step increase or decrease in noise amplitude. Although the artifact of synchrony suppression obscured steady-state ac gain differences between high and low noise levels, the ac gain (in both frog and gerbil) often changed conspicuously over the first few stimulus cycles after a step increase or decrease (i.e., while the noise amplitude was constant). We believe that this is an important aspect of adaptation. We shall prepare a paper on the results this spring.

(3) One-tone suppression (manuscript on the gerbil component submitted to HEARING RESEARCH). The primary-type PSTH (peristimulus time histogram) is typically considered to be the only response pattern of the mammalian auditory nerve fiber to a single tone burst. Although the phenomenon of two-tone suppression is nearly universally accepted in such nerve fibers, one-tone suppression is not--even though it has been reported by reliable sources (e.g., Schmiedt and Zwislocki). Our studies in the bullfrog amphibian papilla suggest that one-tone suppression not only occurs, but that it is an extension of adaptation (i.e., adaptation continuing until the response to a tone has declined to levels below the background spike rate). Our studies in gerbil showed that suppression by a single tone occurs in the absence of any other sound outside of the animal.

(4) Adaptation to cardiac sounds (manuscript submitted to HEARING RESEARCH). Among gerbil primary auditory axons with CFs below 2500 Hz, a substantial subpopulation was found in which spike activity was driven by cardiac-induced sounds (measured in the ear canal). This stimulus seemed to behave as any other acoustic stimulus in its interactions with other sounds. Thus adaptation to the cardiac-induced sounds is expected to alter responsiveness to those other sounds, and the degree of alteration is expected to depend on the relative timing of the two kinds of sounds (i.e., on the phase of the cardiac cycle when the other sounds occur).

(5) CAP Enhancement studies (2 published articles, one in-press manuscript). A forward masker tone typically reduces the amplitude of the cochlear nerve CAP produced by a probe stimulus tone, provided that the frequencies of both tones are similar and that the amplitude of the masker tone is close to (or higher than) that of the probe tone. Increasing the repetition rate of the probe stimulus also results in a decreased CAP amplitude because of adaptation. Both effects also are found at the level of the single cochlear axon, and are believed to be the result of adaptation. We discovered that presentation of a low intensity forward masker (often below the CAP visual detection level) can <u>increase</u> the amplitude of the CAP produced by the probe stimulus. This

effect, termed enhancement, occurs under a very restricted frequency-intensity range of the forward masker, which we have characterized. Several experiments have been performed, showing that conditions that increase adaptation will, up to a certain level, result in enhancement. These conditions include changes of levels of the forward masker and the probe stimulus, the stimulus repetition rate, and the masker-stimulus interval.

Sincerely yours,

Kenneth R. Henry
Co-principal Investigator

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